REMARKS

This is intended as a full and complete response to the Office Action dated June 12, 2003, having a shortened statutory period for response set to expire on September 12, 2003.

Claim Rejections Under 35 U.S.C. § 102(b)

Claims 1, 2, 4-7 stand rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 4,825,071 to Larry L. Gadeken et al (*Gadeken*). Applicant respectfully traverses the rejections.

Naturally occurring radioactive elements are found in nature. The most common of these naturally occurring radioactive elements are isotopes of thorium, radium and potassium. Measures of concentrations of these elements are used in a variety mineralogical and petroleum exploration and evaluation operations. *Gadeken* discloses a logging system for measuring concentrations of these naturally occurring radioactive elements (thorium, uranium and potassium) in material, such as earth formation, penetrated by a well borehole. The logging system comprises a downhole probe or "sonde" 43 that is conveyed along the well borehole (see Fig. 1). The sonde comprises a single gamma ray spectrometer comprising a scintillation crystal 47 and a photomultiplier and amplifier package 48. *The sonde does not contain a source of radiation*. The *Gadeken* logging system determines concentrations of these naturally occurring elements from measures of intensity and energy of naturally occurring gamma radiation emitted by the elements. The *Gadeken* system further corrects the measurements of naturally occurring gamma radiation for attenuation effects of material within the borehole.

The instant invention is a logging system for measuring density of material, and in particular, density of material penetrated by a well borehole. Measures of formation density are used in a variety of mineralogical and hydrocarbon exploration and evaluation operations. The instant invention comprises a downhole "tool" 10 comprising two gamma ray spectrometers (e.g. see Fig. 1) and a *neutron source* 20. Formation density is determined by measuring gamma radiation, *induced within the formation by the neutrons emitted from the neutron source*, using the two gamma ray spectrometers.

Gadeken and the instant invention are designed to measure two completely different parameters of interest. The *Gadeken* system is directed toward measuring parameters of interest which are concentrations of naturally occurring radioactive elements in material penetrated by a borehole. The instant invention is directed toward measuring a parameter of interest, which is the density of material penetrated by a borehole. The *Gadeken* system can not measure formation density. The instant invention can not measure concentrations of naturally occurring radioactive elements in the formation. The *Gadeken* system contains no radioactive source within the logging probe, and obtains parameters of interest from measures of gamma radiation emitted by naturally occurring radioactive elements. The instant invention obtains the parameter of interest from gamma radiation induced within the material by neutrons emitted from a neutron source contained in the logging tool. The *Gadeken* system corrects measurements of interest for effects of the borehole (namely changes in density of

materials in the borehole). The instant invention is mechanically designed to be relatively insensitive to the density of material in the borehole, and respond only to the density of the material penetrated by the borehole.

The elements of the claims 1, 2, and 4 are compared with the *Gadeken* reference.

> 1. A method for determining a property of a material, comprising the steps of:
> (a) inducing, within said material, gamma radiation comprising energies greater than about 3 MeV;

The *Gadeken* system can not *induce* gamma radiation, because it contains no radioactive source. Applicant can find no teaching of induced gamma radiation at col. 3, lines 18-29 as cited by the Examiner. *Gadeken* teaches the detection of gamma radiation in the 20 to 3000 KeV range. This is naturally occurring gamma radiation, as set forth throughout the entire *Gadeken* reference, and not induced gamma radiation. Stated another way, *Gadeken* does not and can not measure induced gamma radiation in this or any other energy range, since no element is available to induce radiation. It is also noted that *Gadeken* does not teach even the measure of naturally occurring gamma radiation greater than about 3 MeV. Naturally occurring gamma radiation above about 3 MeV is rare.

> (b) measuring a first gamma ray spectrum and a second gamma ray spectrum resulting from said induced gamma radiation;

The *Gadeken* system comprises on a single gamma spectrometer and can not, therefore, measure a first and a second gamma ray spectrum as is done in the instant invention using the two gamma ray spectrometers. Col. 3, lines 36-61 cited by the Examiner recites the use of multiple energy regions or "windows" in a single spectrum, not the use of a first and a second spectrum.

> (c) normalizing said first and said second gamma ray spectrum in a first energy region;

Not possible with the *Gadeken* system since only one spectrometer is disclosed.

> (d) measuring down scatter gamma radiation in a second energy region of said normalized first and second gamma ray spectra; and

Not possible with the *Gadeken* system since only one spectrometer is disclosed, as discussed above.

> (e) determining said property from said measure of down scatter radiation.

The *Gadeken* system does not teach determination of a property (e.g. a concentration of a naturally occurring radioactive element) using down scatter radiation.

> 2. The method of claim 1 comprising the additional step of forming said induced gamma radiation by means of a neutron source.

Nowhere at col. 3, lines 18-29 (as cited by the Examiner), or anywhere in the disclosure, does *Gadeken* disclose or even suggest the use of a neutron source or any other type of radiation source.

4. The method of claim 1 wherein said property is bulk density.

The bulk density term used in equation (4) (col. 6, line 18 as cited by the Examiner) is used only for tutorial purposes to define "electron density". The *Gadeken* system is directed toward correcting for changes in bulk density of material <u>in the borehole</u>, and not directed toward measuring density of the formation penetrated by the borehole.

In view of the above comparisons, claims 1, 2 and 4 are clearly <u>not</u> anticipated by *Gadeken*. Claims 5-7 are dependent upon claim 1. In view of the discussion related to claim 1, dependent claims 5, 6 and 7 are clearly not anticipated by *Gadeken*.

In view of the above discussion, the Examiner is respectfully requested to reconsider rejection of claims 1, 2, 4-7 35 U.S.C. § 102(b) as being anticipated by *Gadeken*.

Claims 8, 9, 11, 13-19, 21, and 24-26 stand rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent No. 3,864,569 to Jay Tittman (*Tittman*). Applicant respectfully traverses the rejections.

Tittman discloses a logging system for measuring density of earth formation penetrated by a well borehole. The *Tittman* logging instrument comprises a <u>gamma ray</u> source 21. The source is preferably cesium-137 which emits gamma radiation at about 660 KeV or 0.660 MeV (see col. 3, lines 48-54). Two axially spaced gamma ray detectors are used to measure gamma radiation emitted by the source and back scattered by the formation. These measures of gamma radiation are combined to yield a measure of formation density

Tittman and the instant invention utilize completely different apparatus and methods to obtain formation density measurements. The *Tittman* system also has operational limitations while the instant invention can be operated in a much wider range of conditions, as will be discussed subsequently. The *Tittman* system obtains a formation density measurement by detecting gamma radiation that is emitted by a <u>gamma ray source</u> and is subsequently back scattered into the well borehole. The instant invention obtains a formation density measurement by detecting gamma radiation <u>induced</u> in formation by a <u>neutron source</u>. *Tittman* uses relatively low energy gamma radiation, which is less than the maximum source energy. The maximum source energy is about 0.660 MeV for the preferred cesium-137. The instant invention measures higher energy gamma radiation (e.g. 4.43 MeV). The *Tittman* system is limited to wireline logging applications. The instant invention can be uses both in wireline logging and in logging-while-drilling operations.

Regarding claims 8, 9, 11, and 13-17, independent claims 8 clearly recites inducing gamma radiation by means of a <u>neutron</u> source at element (a), and detecting

gamma radiation <u>induced</u> by the neutron source at elements (b) and (c). The Examiner, citing col. 2, lines 40-41 and col. 3, lines 49-54, erroneously states that *Tittman* discloses an apparatus for measuring a property of material, comprising a <u>neutron</u> source. Col. 2, line 41 specifically recites that the *Tittman* tool contains a <u>gamma ray</u> source. Furthermore, col. 3, lines 49-54 specifically recite a <u>cesium-137 gamma ray source</u>. Independent claim 8 is, therefore, clearly distinguished over *Tittman*. Claims 9, 11, 13-17, which depend upon independent claim 8, are also clearly distinguished over *Tittman*.

Claim 17 recites an additional method of conveying the tool with a drill string. This feature further distinguishes the instant invention over *Tittman*. The *Tittman* logging instrument is a pad type device. If such a device were mounted on a drill string, and the drill string were rotated to advance the borehole, the pad would immediately be "sheared" off and the system would be <u>inoperable</u>. The instant logging tool is <u>not</u> a pad type device, and is therefore applicable to drill string conveyance and logging-while-drilling applications. Both wireline and logging-while-drilling embodiments of the instant logging system are discussed in detail in the instant specification. Regarding claim 17, segments of the *Tittman* specification cited by the Examiner at col., line 61 to col. 2, line 3, and col. 3, lines 26-33, are not pertinent. These segments are directed toward how mudcake is formed in drilling a borehole. They do <u>not</u> teach or imply conveying the pad type *Tittman* logging instrument with a drill string, or using the *Tittman* system in logging-while-drilling operations.

Regarding claims 18, 19, 21, and 24-26, independent claim 18 clearly recites a <u>neutron</u> source at element (a). Again, the *Tittman* tool comprises a <u>gamma ray</u> source. Claim 18, and dependent claims 19, 21, and 24-26 are therefore clearly distinguished over *Tittman*

Claim 26, similar to claim 17, recites means for conveying the logging tool by means of a drill string. Claim 26 further distinguish the instant invention over *Tittman*. The *Tittman* logging instrument is a pad type device, and will be destroyed if operated with a rotating drill string, as detailed in the discussion of claim 17 above.

In view of the above discussion, the Examiner is respectfully requested to reconsider rejection of claims 8, 9, 11, 13-19, 21, and 24-26 under 35 U.S.C. § 102(b) as being anticipated by *Tittman*.

<u>Claim Rejections Under 35 U.S.C. § 103(a)</u>

Claim 3 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over *Gadeken* in view of *Tittman*. Applicant respectfully traverses the rejection.

Gadeken discloses a system that contains <u>no</u> source. *Tittman* discloses a system that contains a <u>gamma ray</u> source. Furthermore, the *Tittman* source is preferably an isotopic cesium-137 source that emits gamma radiation at a maximum energy of about 0.660 MeV. All other known isotopic gamma ray sources (such as cobalt-60) emit gamma radiation below 2 MeV. No gamma radiation measured by the *Tittman* system, resulting from the gamma ray source, can exceed the maximum energy of the gamma ray source. Any hypothetical combination of *Gadeken* and *Tittman* would therefore yield a logging system comprising tool with (a) a <u>gamma ray</u> source and (b) detectors responsive to back scattered gamma radiation, wherein energy of the back scattered gamma radiation

would be less that 2 MeV, and preferably less that 0.660 MeV (which is the maximum energy of preferred Cesium-137 source). Considering Applicants' claim 3 depends upon claim 2, and claim 2 depends upon claim 1, claim 3 effectively recites the additional limitations of (a) inducing gamma radiation comprising energies greater than about 3 MeV (from element (a) of claim 1), wherein this gamma radiation is induced with a neutron source (claim 2).

In summary, (a) there is no teaching in the prior art that suggests combining *Gadeken* and *Tittman* to obtain a measure of formation density which measures high energy gamma radiation induced in the formation by a neutron source, (b) a combination of *Gadeken* and *Tittman* would not yield a system which measures formation density using measures of high energy gamma radiation induced in the formation by a neutron source, (c) it would not be obvious to one of ordinary skill in the art to even try to combine *Gadeken* and *Tittman* to measure formation density using induced high energy gamma radiation, and (d) *Gadeken* and *Tittman* are nonanalogous art in that the former system is designed to correct naturally occurring gamma ray measurements for borehole effects, and the latter is designed to measure formation density. No hypothetical combination of *Gadeken* and *Tittman* teaches or suggests claim 3 with intervening limitations of claim 1 and 2. Claim 3 is, therefore, patentable over *Gadeken* in view of *Tittman*. In view of the above discussion, the Examiner is respectfully requested to reconsider rejection of claim 3 under 35 U.S.C. § 103(a) as being unpatentable over *Gadeken* in view if *Tittman*.

Claims 10 and 22 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over *Tittman* in view of U.S Re. 36,012 to William A. Loomis et al (*Loomis*). Applicant respectfully traverses the rejections.

Loomis discloses a logging system that is designed to measure a variety of formation parameters, including density and porosity, by detecting neutron and gamma radiation induced within the formation by a neutron source. Gamma radiation up to 10 MeV is measured. A bottom hole assembly 36 houses an accelerator source 58 and clusters of axially spaced detectors comprising both neutron and gamma ray detectors (e.g. 66a, 66b, 66c and 66d). The bottom hole assembly also includes a detector 62, which responds primarily to the accelerator output (see col. 6, lines 53-58). Such a detector is commonly referred to a neutron source monitor. Response of the neutron monitor 62 is used to correct or "normalize" the measured responses of the other detectors for variations in neutron output from the accelerator in order to obtain accurate determination of formation parameters of interest.

Claim 10 (dependent upon claim 8) and intervening claims recite the use of only a first and a second gamma radiation spectra energy regions of about 3 MeV to about 7 MeV, and from about several hundred keV to about 3 MeV, respectively, to obtain a measure of density. No neutron measurements are required. No monitoring of neutron source output is required. Claim 22 recites two gamma ray spectrometers. No neutron detectors are recited. No accelerator monitor is recited.

In summary, any hypothetical combination of the system of *Tittman* with the system of *Loomis* would include a plurality of neutron radiation detectors, a plurality of gamma radiation detectors, and a neutron monitor detector 62. The hypothetical

combination comprises more elements of differing types than required by the instant invention. The hypothetical combination would also require more data processing steps than the instant invention. Claims 10 and 22 are clearly patentable over *Tittman* in view of *Loomis*. In view of the above discussion, the Examiner is respectfully requested to reconsider rejection of claims 10 and 22 under 35 U.S.C. § 103(a) as being unpatentable over *Tittman* in view if *Loomis*.

Claims 12 and 23 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over *Tittman* in view of U.S 5,767,510 to Michael L. Evans (*Evans*). Applicant respectfully traverses the rejections.

Evans discloses a logging system comprising a Californium-252 neutron source. *Tittman* discloses a logging system comprising a gamma ray source.

There is no teaching in the prior art to suggest the use of the neutron source of *Evans* in a logging system designed to used a gamma ray source, such as the pad type density logging system of *Tittman*. Furthermore, the use of the neutron source of *Evans* in the gamma ray logging system of *Tittman* would simply not work. *Tittman* determines density from gamma radiation back scattered from a relatively low energy gamma ray source. Detector collimation, pad design, detector energy biasing, and system calibration of the *Tittman* logging are all designed to measure this relatively low energy back scatter gamma radiation. The substitution of the *Evans* neutron source for the *Tittman* gamma ray source would produce neutron and neutron induced gamma radiation radiation fluxes, at the *Tittman* detectors, which would not meet design criteria of the *Tittman* system and which the *Tittman* system could not measure, and process. As a result, no measure of formation density could be obtained using a combination of *Tittman* and *Evans*. Claims 12 and 23 are, therefore, clearly patentable over *Tittman* in view of *Evans*. In view of the above discussion, the Examiner is respectfully requested to reconsider rejection of claims 12 and 23 under 35 U.S.C. § 103(a) as being unpatentable over *Tittman* in view if *Evans*.

Claim 20 stands rejected under 35 U.S.C. § 103(a) as being unpatentable over *Tittman* in view of *Gadeken*. Applicant respectfully traverses the rejection.

Reference in made to the discussion above of claim 3. There is no teaching in the prior art that suggests combining a system comprising an isotopic gamma ray source (*Tittman*) with a system comprising no source (*Gadeken*) to induce gamma radiation in formation material with energy greater than 3 MeV. A hypothetical combination of *Tittman* and *Gadeken* would simply not yield methodology and results of the instant invention. Claim 20 is clearly patentable over *Tittman* in view of *Gadeken*. In view of the above discussion, the Examiner is respectfully requested to reconsider rejection of claim 20 under 35 U.S.C. § 103(a) as being unpatentable over *Tittman* in view if *Gadeken*.

The Examiner is respectfully requested to consider the above remarks and to allow pending claims 1-29 as filed.